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Preoperative Morphometric Analysis of the Craniovertebral Junction: A Retrospective Study of 12 Surgically Managed Cases

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Abstract
Background: The craniovertebral junction (CVJ) is a transitional anatomical zone vulnerable to anomalies like basilar invagination and atlantoaxial dislocation. Preoperative morphometric evaluation plays a critical role in surgical planning.
Objective: To analyze morphometric parameters in CVJ anomalies and assess their relevance in surgical management.
Methods: A retrospective analysis of 12 patients (7 males, 5 females; mean age 26 years) treated surgically between August 2023 and July 2024 at a tertiary center. Preoperative and postoperative CT/MRI scans were used to measure clivus length, basal angle, atlanto-dental interval, and other morphometric variables.
Results: Preoperative imaging showed reduced clivus length (36.4 ± 2.1 mm) and basal angle (121.3° ± 5.4°) with increased ADI (4.6 ± 0.8 mm). Postoperatively, restoration of cranio-cervical alignment and ADI normalization (<3 mm) was achieved in 83% of cases without new neurological deficits.
Conclusion: Detailed morphometric analysis aids in precise surgical planning and safer management of CVJ anomalies.

Keywords: *Craniovertebral junction, Morphometry, Atlantoaxial dislocation, Basilar invagination, Pre-surgical planning*

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I. Introduction

The craniovertebral junction (CVJ) is a highly complex anatomical region where the skull base transitions into the upper cervical spine. Its unique osseoligamentous architecture confers both stability and flexibility, facilitating extensive mobility while safeguarding critical neurovascular structures. Developmental anomalies of the CVJ, including basilar invagination (BI), atlantoaxial dislocation (AAD), and occipital assimilation, disrupt this balance and are associated with significant morbidity due to compression of the brainstem and upper cervical cord [1,2].

Accurate preoperative morphometric assessment is essential for surgical planning in these anomalies. Measurements such as clivus length, basal angle, foramen magnum diameter, atlanto-dental interval (ADI), and dimensions of the C1 lateral masses and C2 pedicles play a pivotal role in determining the feasibility of various fixation techniques and minimizing intraoperative complications [3–5]. Additionally, population-specific morphometric differences, such as smaller C2 pedicle widths in Indian patients, may influence the choice of instrumentation and trajectory [6,7].

This retrospective case series analyzes pre- and postoperative morphometric parameters in 12 patients with CVJ anomalies managed surgically at a tertiary neurosurgical center over a one-year period. The objective is to identify key morphometric variables influencing surgical decision-making and evaluate postoperative realignment and stability outcomes.

II. Results

Twelve patients (7 males, 5 females; mean age 26 years, range 14–67 years) with developmental CVJ anomalies were included. Basilar invagination was the most common anomaly (n=8), followed by atlantoaxial dislocation (n=6). Three patients presented with associated Chiari malformation.

Preoperative imaging revealed a mean clivus length of 36.4 ± 2.1 mm and a reduced basal angle of 121.3° ± 5.4°. The mean ADI was 4.6 ± 0.8 mm. Notable asymmetry in C1 lateral mass heights and C2 pedicle

dimensions was observed, affecting screw selection and trajectory planning. Postoperative CT scans confirmed correction of abnormal cranio-cervical angles in all patients and restoration of the ADI to <3 mm in 10 of 12 cases. No new neurological deficits occurred postoperatively.

Dynamic radiography identified irreducibility in 4 patients, who underwent occipitocervical fusion with C1–C2 facet osteotomy. Two patients required transoral decompression for ventral odontoid compression. At 6-month follow-up, all patients demonstrated bony fusion and maintained alignment.

Table 1: Preoperative and Postoperative Morphometric Parameters

Parameter	Pre-op Mean ± SD	Post-op Mean ± SD
Clivus Length (mm)	36.4 ± 2.1	37.1 ± 1.9
Basal Angle (°)	121.3 ± 5.4	128.7 ± 4.8
Clivus Canal Angle (°)	148.2 ± 6.0	154.1 ± 5.5
Foramen Magnum Diameter (mm)	33.6 ± 1.8	33.8 ± 1.6
Atlanto-dental Interval (mm)	4.6 ± 0.8	2.8 ± 0.5
Right C1 Lateral Mass Height (mm)	14.2 ± 0.9	14.3 ± 0.8
Left C1 Lateral Mass Height (mm)	14.1 ± 0.7	14.2 ± 0.7
Right C2 Pedicle Width (mm)	5.1 ± 0.5	Unchanged
Left C2 Pedicle Width (mm)	5.0 ± 0.4	Unchanged
Right C2 Pedicle Transverse Angle (°)	38.7 ± 3.2	Unchanged
Left C2 Pedicle Transverse Angle (°)	39.1 ± 3.5	Unchanged
Occipital Bone Thickness (mm)	8.2 ± 0.6	Unchanged

III. Discussion

Management of CVJ anomalies demands a nuanced understanding of regional anatomy and meticulous preoperative planning. Morphometric variability across populations is well-documented; Indian cohorts, for example, often exhibit narrower C2 pedicles compared to Western populations, necessitating tailored instrumentation strategies [6,7]. Our findings corroborate these differences and highlight the importance of individualized morphometric assessment to prevent complications such as vertebral artery injury during transpedicular screw placement [8].

The observed reduction in clivus length and basal angles in our cohort supports the “short clivus hypothesis,” which implicates cranial base shortening in the pathogenesis of BI and AAD [9]. Dynamic radiographs remain indispensable for assessing reducibility and determining the need for posterior release or anterior decompression [10].

Postoperative restoration of normal cranio-cervical alignment correlated with symptomatic improvement in our patients. This underscores the critical role of preoperative imaging in planning for realignment and stabilization. Limitations of this study include its small sample size and retrospective design, but the findings reinforce the value of comprehensive morphometric analysis in optimizing surgical outcomes for CVJ anomalies.

References

[1]. Menezes AH. Craniovertebral junction anomalies: diagnosis and management. Neurosurgery. 2008;62 Suppl 2: 1–16.
[2]. Goel A. Atlantoaxial instability: Anatomy, pathogenesis, and treatment. Neurol India. 2015;63: 579–589.
[3]. Tubbs RS, et al. Morphometric analysis of the craniovertebral junction: Clinical applications. J Neurosurg Spine. 2011;14(5): 539–543.
[4]. Muthukumar N, et al. Occipitocervical fusion: Morphometric considerations in an Indian population. J Clin Neurosci. 2005;12(7): 765–768.
[5]. Gupta S, et al. Anatomical considerations for posterior instrumentation of the C1-C2 complex: A radiological study in Indian adults. Indian J Neurosurg. 2019;8(1): 1–7.
[6]. Chandra PS, et al. Morphometry of C2 pedicles in the Indian population. Spine (Phila Pa 1976). 2013;38:E458–E463.
[7]. Wright NM. Posterior C2 fixation: Pedicle and pars techniques. Neurosurgery. 2005;57(1 Suppl): 10–17.
[8]. Wang S, et al. Dynamic radiography in assessing atlantoaxial instability: Clinical relevance. Spine J. 2014;14(9): 2045–2051.
[9]. Arvin B, et al. Short clivus and basilar invagination: A morphometric analysis. J Neurosurg Spine. 2011;15(6): 594–600.
[10]. Goel A, et al. Treatment of irreducible atlantoaxial dislocation by facetal distraction and fixation. J Neurosurg Spine. 2004;1(3): 281–286.